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EQUIPMENT FOR A PULSE METHOD OF SOUND VELOCITY MEASUREMENT IN R--ETC(U)

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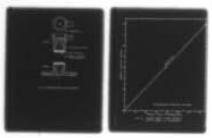

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EQUIPMENT FOR A PULSE METHOD OF SOUND

VELOCITY MEASUREMENT IN ROCK AND SEDIMENT

by

George Shumway and S. H. Abernethy

This memorandum has been prepared because it is believed that the information may be useful in this form to others at NEL and to a few persons and activities outside of NEL. This memorandum should not be construed as a report, as its only function is to present for the information of others a portion of the work which was done on the above-mentioned problem.

The most frequently used laboratory technique for measuring the velocity of compressional elastic waves in rock specimens, sediments, and other materials is the so-called pulse method in which the travel time of acoustic pulses over a known path length in a specimen is determined. Resonance techniques have been used to good advantage also, however. Each method has certain advantages and disadvantages that must be reckoned with. over

Resonance methods have been used not only for measuring compressional velocities in rock samples, but also for measuring torsional wave velocities and sound absorption (Ide, 1935; Ide, 1936; Birch, 1937; Ide, 1937; Birch and Bancroft, 1938; Birch and Bancroft, 1940; Birch, 1943). Resonant methods were used to study the elastic properties of soils and sands by Ishimoto and Iida (1936, 1937), Iida (1938, 1940), and Shumway (1956, 1958, 1960). Resonance methods as they have been used employ acoustic frequencies in the audio range whereas pulse methods used in the laboratory employ much higher acoustic frequencies. An advantage of the resonance method is that a measure of mechanical Q, and therefore a measure of the absorption of sound, is readily obtained even on a relatively small sample, whereas with the pulse method extra equipment must be set up for making sound absorption measurements, and a somewhat larger sample must be used.

Pulse methods have been used by a number of people, including Hughes and Jones (1950), Hughes and Cross (1951), Hughes and Jones (1951), Hughes and Kelly (1952), Wyllie, Gregory and Gardner (1956), Paterson (1956), Laughton (1954, 1957), Sutton, Berckhemer and Nafe (1957), and Busby and Richardson (1957). The pulse method is readily used for studies at high pressures.

The pulse equipment described here was set up to be a permanent facility of the Sea Floor Studies Section, for use both with rocks and other solid materials, and with sediments. A water-jacket is provided so that water-saturated sediments and rocks can be measured.

The equipment basically consists of two transducers, one of which supplies acoustic pulses to the sample being measured and the other receiving the pulses after they have traveled a certain distance through the sample ~~(Figs. 1 and 2)~~. The received signal is displayed on an oscilloscope screen and the travel time determined there by the operator who picks the first arrived signal by eye. The transmitting transducer is activated by pulses from a General Radio Company Unit Pulser, Type No. 1217-A, with Unit Power Supply Type No. 1203-A. A Du Mont Type 256-D cathode-ray oscilloscope serves well for the signal display. This ancient instrument, of World

War II vintage, has a movable marker controlled by a dial calibrated in microseconds, which makes it possible to determine delay (travel) times directly, and more accurately than could be done on a scope not having this movable marker feature.

The pulser is operated at a pulse repetition rate of either 200 c/s or 500 c/s, and a pulse duration lying between 500 and 2000 microseconds is used. The output of the receiving transducer is amplified by a Hewlett Packard Model 450A amplifier before being fed to the video input of the oscilloscope.

The upper transducer is connected to a hydraulic ram which makes it possible to squeeze the sample between the two transducers to whatever degree is necessary to assure good acoustic coupling.

The transducers consist of discs of barium titanate 20.6 mm in diameter and about 6 mm thick. These are mounted in a cast plastic which fills conical cavities in the stainless steel mounts that are used (Fig. 3). The conical cavities serve as horns to minimize possible troublesome sound radiation from the back surface of the transducers.

When the water jacket is filled with water a specimen held between the transducers is totally immersed. This makes

it possible to work with water-saturated porous rocks and other materials. It can be difficult to completely resaturate a porous fine-grained rock once it has partially dried out, hence it is desirable when working with wet specimens to keep them immersed almost continuously. By collecting rock samples underwater, drilling cores from them in the laboratory while they are immersed, and then measuring their sound velocities while immersed, problems of the introduction of air are eliminated. The presence of water in the water jacket should not, and apparently does not, affect the travel time of the first arrived signal to any extent noticeable or measurable, provided the sample has a sound velocity greater than that of water. If the sample's sound velocity be less than that of water then the presence of water will provide a possible sound path between transducers with a shorter travel time than that through the sample, and the measured sound velocity may not represent the sample. Among earth materials, only high-porosity unconsolidated silt and clay sediments are likely to have sound speeds less than water, and of necessity these will be confined in a container for measurement, so the problem of water need not arise.

A series of lucite rods one inch in diameter and of varying lengths between 0.5 and 8 inches were used to verify the operation

of the apparatus (Fig. 4). Travel times through the various rods as a function of length produced a linear relationship which terminates at a zero travel time for a zero sample length and which has a slope representing a sound speed of 8890 ft/s.

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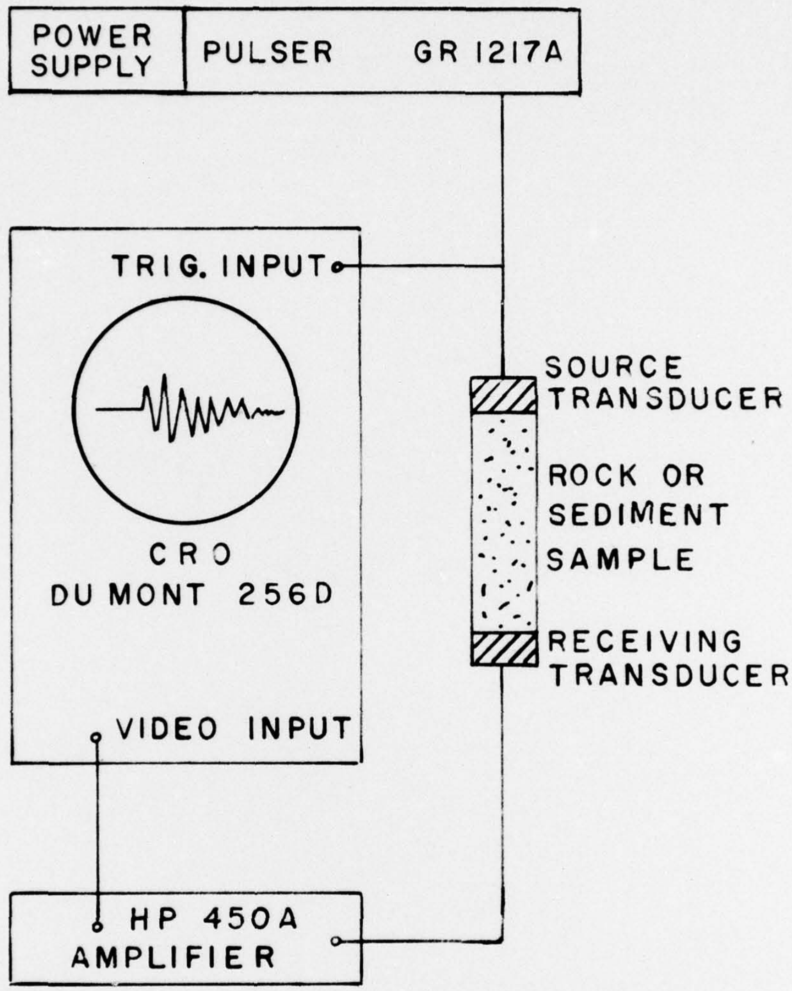

FIG. I. COMPONENTS OF SOUND VELOCITY APPARATUS

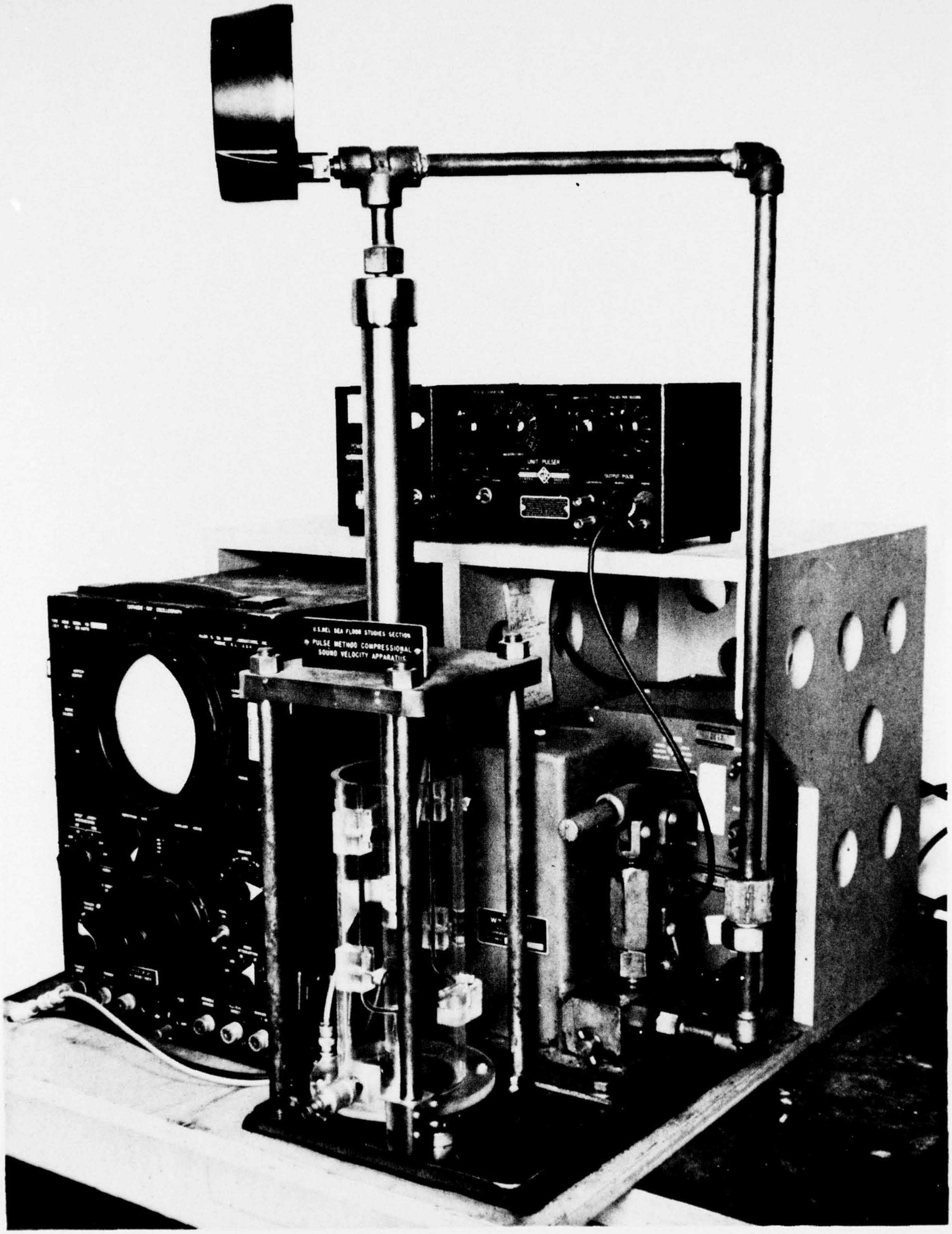

FIG. 2 PULSE METHOD SOUND VELOCITY APPARATUS

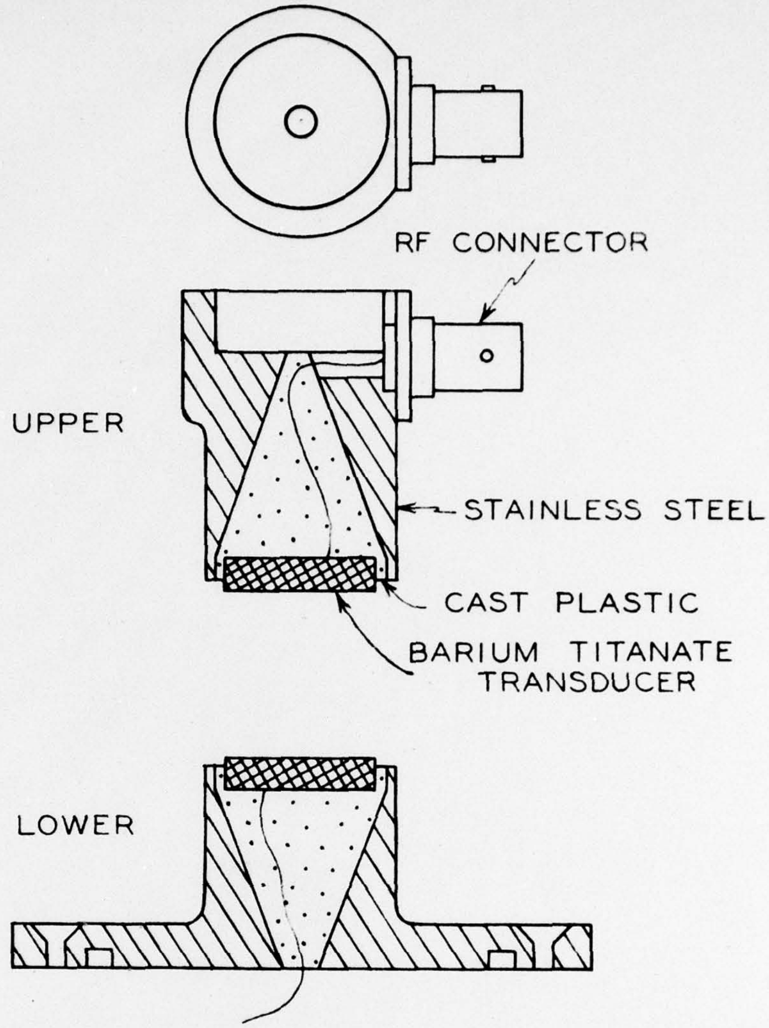

FIG. 3. TRANSDUCERS AND MOUNTS

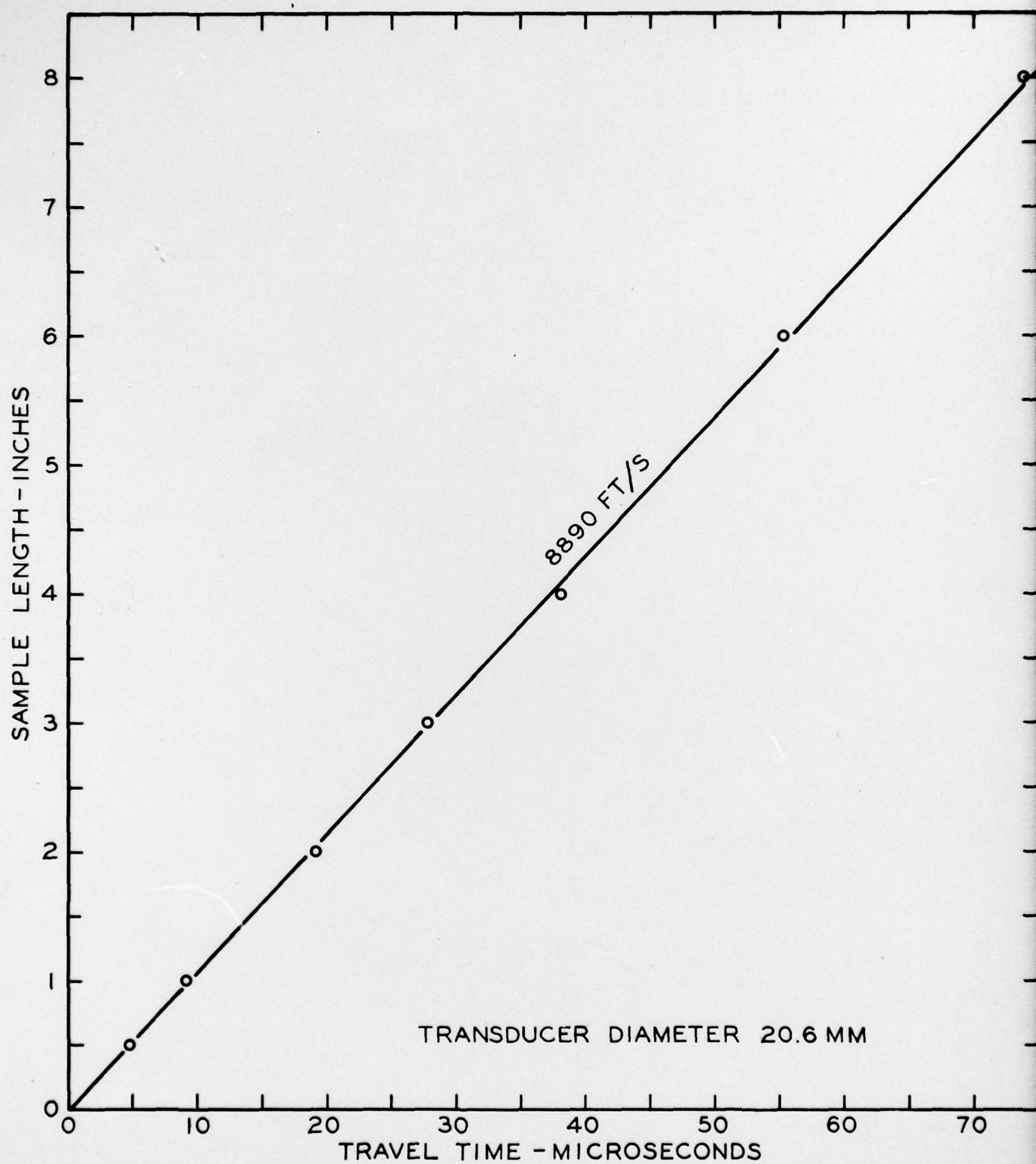

FIG. 4. SOUND TRAVEL TIME THROUGH LUCITE RODS 1 IN. DIAMETER